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A Design Guide for Energy-Efficient Research Laboratories

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FOREWORD

A Design Guide for Energy-Efficient Research Laboratories -- is intended to assist facility owners, architects, engineers, designers, facility managers, and utility energy-management specialists in identifying and applying advanced energy-efficiency features in laboratory-type environments. This Guide focuses comprehensively on laboratory energy design issues with a "systems" design approach. Although a laboratory-type facility includes many sub-system designs, e.g., the heating system, a comprehensive design approach should view the entire building as the essential "system." This means the larger, macro energy-efficiency considerations during architectural programming come before the smaller, micro component selection such as an energy-efficient fan. We encourage readers to consider the following three points when utilizing the Guide.

1. Since the Guide's focus is energy efficiency, it is best used in conjunction with other design resources, manuals, handbooks, and guides. This Guide is not meant to supplant these resources but rather to augment them by facilitating the integration of energy-efficiency considerations into the overall design process.

2. Though the Guide may seem to push the envelope of traditional engineering design practice, its recommendations are widely used in actual installations in the United States and abroad. We believe that successful design teams build from the members' combined experience and feedback from previous work. Each team should incorporate energy efficiency improvements, as appropriate, by considering their interactions and life-cycle costs. We also recognize that there is no single design solution for all situations; thus, the Guide focuses on conceptual approaches rather than prescriptive measures.

3. We have performed an extensive literature search and present brief excerpts from many excellent publications. We encourage readers to obtain the full citation of interesting and pertinent documents.

GUIDE INSTALLATION WITH DISKETTE

The Guide is installed on your computer in the Windows 95/98™ environment as a “help” file. Insert diskette number one (1) into your computer's 3.5 inch floppy drive (typically the "A" drive) and with your mouse select from the desktop tool bar: "Start"; "Run"; and then with the keyboard type "a:\setup" (where "a" is your 3.5 inch floppy drive letter); and press enter. Follow screen prompts to complete installation. The Guide's Help File is best displayed by setting your Browsing Options to "Browse folders using a separate window for each folder" (by selecting "My Computer/View/Options").

GUIDE INSTALLATION FROM INTERNET

You can also visit our Internet "home page" to use and download the latest Guide version at: http://ateam.lbl.gov/Design-Guide/ (please note that this address is <u>not</u> case sensitive).

GUIDE CONTENTS

As a self-supporting help file, the Guide includes: full index search capabilities by subject, topic, and referenced author; and free-text searching that allows plain English inquiries with "AnswerHelp", similar to an "answer wizard". This generation of the Guide includes over 1800 embedded "hypertext" jumps. A brief outline of the Guide follows:

"HOT TOPICS" for RESEARCH LABORATORY ENERGY EFFICIENCY

When an engineer is familiar with the Hot Topics of energy-efficient laboratory design, solutions will develop to provide a comprehensive design that creates a smoothly operating facility with a low life-cycle cost.

- **Integrated System Design: Right-Sizing for Energy Efficiency**

The techniques of right-sizing integrate the many interactive relationships that influence the capacity of the environmental conditioning system. The goal of right-sizing is to prevent over design of the space-conditioning system; excessive capacity in a large system wastes energy and increases first costs. The engineering team must determine whether the facility's design conditions are overstated; typically, the specified comfort envelope can be enlarged, reducing the required conditioning system capacity. Another Right-Sizing technique is appraisal of conditioning system diversity, which is based on the assumption that all laboratory equipment is unlikely to operate simultaneously; a diversity analysis determines the average system capacity that will accommodate part-load operation. A Variable Air Volume (VAV) system can efficiently accommodate part-load operation. Chapter 3 of the Guide elaborates diversity design principles. For analysis of safe, energy-efficient application of VAV supply systems, see Chapter 5; for VAV exhaust systems, see Chapter 6.

- **Energy Monitoring and Control System with Direct Digital Control**

An Energy Monitoring and Control System (EMCS) that incorporates direct digital control (DDC) is a key element to an energy-efficient research laboratory. If it is properly designed, installed, and maintained the EMCS insures energy-efficient operation of the facility by monitoring, controlling, and tracking energy consumption. Traditionally, EMCSs have been provided to facilities by manufacturers with little input from design team engineers. It is strongly recommended that energy engineers take a more proactive role in EMCS selection from the design of the sequence of operations to the specification of the kinds of sensors and operators to be installed. See Chapter 4.

- **Variable Frequency Drives (VFDs) and Air Flow Rates**

Air handling equipment is typically sized so that it operates at only 70 percent of its full-load rating. Incorporating a variable frequency drive (VFD) that uses duct static pressure as a control input can pay for itself in less than two years. The VFD's lower air velocity reduces pressure loss and increases operating efficiency of a heat recovery device if one is present; these improvements more than compensate for higher system first costs. When the laboratory is unoccupied, the rate could be reduced to 50% of the nominal value, decreasing the energy consumption of the entire air handling system to less than 25% of that required for a conventional system, provided safe minimum ventilation is maintained. See Chapters 3, 5, and 6.

- **Modularized Plant Devices**

Conditioning equipment can be designed in modules that can operate singly or together to meet part or full loads. Modules include multiple boilers and chillers that can have their operation staged to meet the load. Devices whose operation can be ranged include Variable Air Volume (VAV) supply and fume hood exhaust systems and Variable Frequency Drives (VFDs) on fans and pumps. EMCSs can modulate heating and cooling temperatures with real-time precision. All of these modules and devices take advantage of the facility's diversity and maximize system part-load efficiency. See Chapter 5.

- **Segregating Tasks with Minienvironments**

Laboratory temperature and humidity design conditions are typically specified to satisfy both process and human comfort needs. Segregating the more tightly controlled areas from other non-critical areas saves energy. One method is to subdivide systems and zones with minienvironments, see Chapter 2.

- **Indirect-Direct Evaporative Cooling**

The greater the range of allowable humidity, the greater the energy savings. As the allowable humidity range increases, the use of energy-efficient indirect-direct evaporative cooling becomes more appropriate. Depending upon climate, when a laboratory's required relative humidity range is 45 to 50 percent, evaporative cooling can be used. This approach can consume as little as two-thirds of the energy necessary to provide a range of 40 to 45 percent R.H., assuming this lower humidity range requires the use of a chiller. Laboratories in warmer climates benefit from raising the allowable R.H.; laboratories in colder climates benefit most from lower minimum R.H. specifications as well as a wider range. See Chapter 3 and 5.

- **Other Measures**

Numerous other measures can be employed in an energy-efficient laboratory conditioning system. The list below provides a quick overview of some additional energy-efficient solutions reviewed in the Guide:

- recover heat from the exhaust air or process cooling water with run-around coils; recover both sensible and latent energy with heat wheels
- incorporate low-face-velocity coils and filters
- choose the lowest pressure drop filter for the efficiency required
- utilize free cooling with a plate-and-frame heat exchanger instead of the chiller and oversized cooling towers
- minimize energy-intensive air cooling and humidification by using evaporative cooling
- use premium efficiency equipment when selecting motors, lamps, boilers, chillers, fans, etc.
- use variable outside air for support spaces that have economizers
- reuse air from office/support spaces to reduce the need for mechanical cooling in the laboratories
- use chiller waste heat for heating purposes.

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